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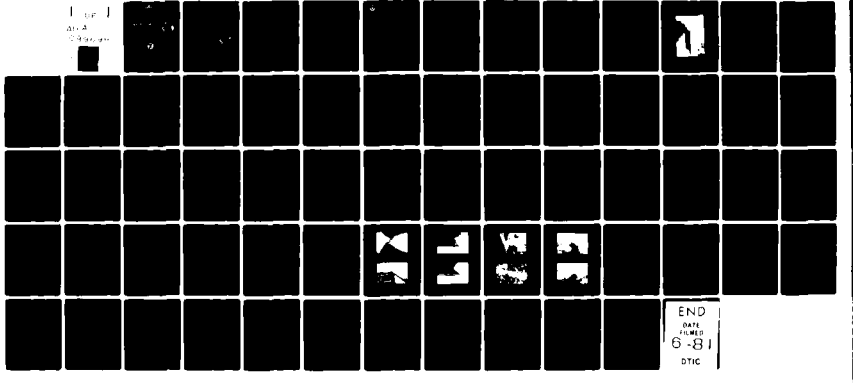

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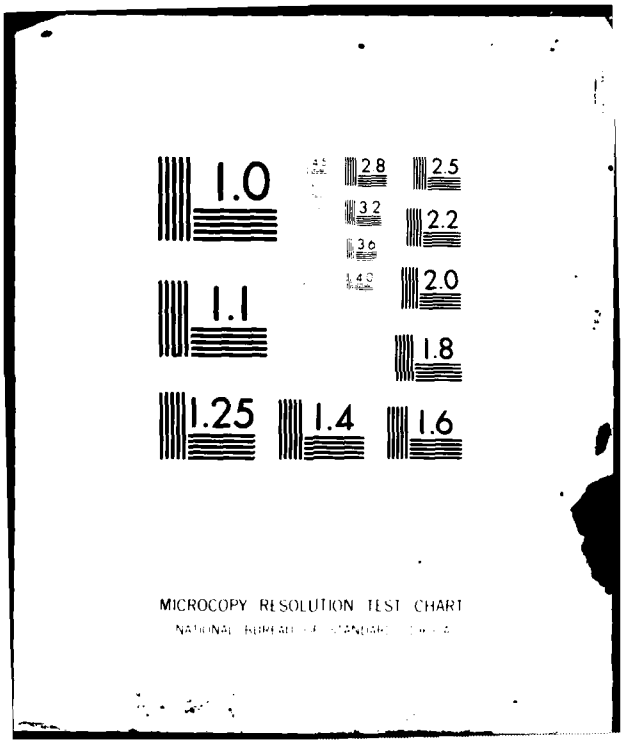
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WARREN/HUNTERDON COUNTIES
NEW JERSEY

WARREN MILL DAM
NJ 00765

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DACW61-79-C-0011

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

Rept. no. DAENAP-53842/NJ00765-81/03

MARCH 1981

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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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National Dam Safety Program
Warren Mill Dam, N.J.
Spillways
Seepage
Embankment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

28 MAY 1981

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Warren Mill Dam in Hunterdon County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Warren Mill Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection is judged to be in poor overall condition. The dam's spillway is considered adequate. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Temporary concrete patching of the deteriorated portions of the spillway should be undertaken within thirty days from the date of approval of this report to forestall further damage.

b. The following remedial actions should be initiated within six months from the date of approval of this report:

(1) Initiate engineering studies, including structural and foundation investigations, in order to plan and design longterm repairs for the spillway structure.

(2) Remove heavy siltation on the upstream side of the spillway to reduce the load on the structure and to increase storage capacity.

(3) Monitor seepage at the toe of the spillway, both before and after the removal of the silt behind the spillway, and implement a grouting program if warranted.

(4) Stabilize the downstream stilling basin below the apron with riprap to prevent further scouring.

(5) Regrade the eroded areas behind the spillway sidewalls and protect these areas with stone riprap.

(6) Remove trees growing on the embankment portion of the dam.

c. The owner should institute written operation and maintenance procedures in conjunction with their present operations such that regular dam inspections are conducted and routine maintenance and remedial actions are accomplished on a timely basis. Inspection and maintenance checklists should be kept in order to provide continuity in the data regarding the dam's condition in the future. This should be initiated within one year from the date of approval of this report.

d. The owner should develop an emergency action plan and a downstream warning system within six months from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Courter of the Thirteenth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

WARREN MILL DAM (NJ00765)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 28 August 1980 by Louis Berger and Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Warren Mill Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection is judged to be in poor overall condition. The dam's spillway is considered adequate. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Temporary concrete patching of the deteriorated portions of the spillway should be undertaken within thirty days from the date of approval of this report to forestall further damage.

b. The following remedial actions should be initiated within six months from the date of approval of this report:

(1) Initiate engineering studies, including structural and foundation investigations, in order to plan and design longterm repairs for the spillway structure.

(2) Remove heavy siltation on the upstream side of the spillway to reduce the load on the structure and to increase storage capacity.

(3) Monitor seepage at the toe of the spillway, both before and after the removal of the silt behind the spillway, and implement a grouting program if warranted.

(4) Stabilize the downstream stilling basin below the apron with riprap to prevent further scouring.

(5) Regrade the eroded areas behind the spillway sidewalls and protect these areas with stone riprap.

(6) Remove trees growing on the embankment portion of the dam.

c. The owner should institute written operation and maintenance procedures in conjunction with their present operations such that regular dam inspections are conducted and routine maintenance and remedial actions are accomplished on a timely basis. Inspection and maintenance checklists

should be kept in order to provide continuity in the data regarding the dam's condition in the future. This should be initiated within one year from the date of approval of this report.

d. The owner should develop an emergency action plan and a downstream warning system within six months from the date of approval of this report.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 20 May 1981

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

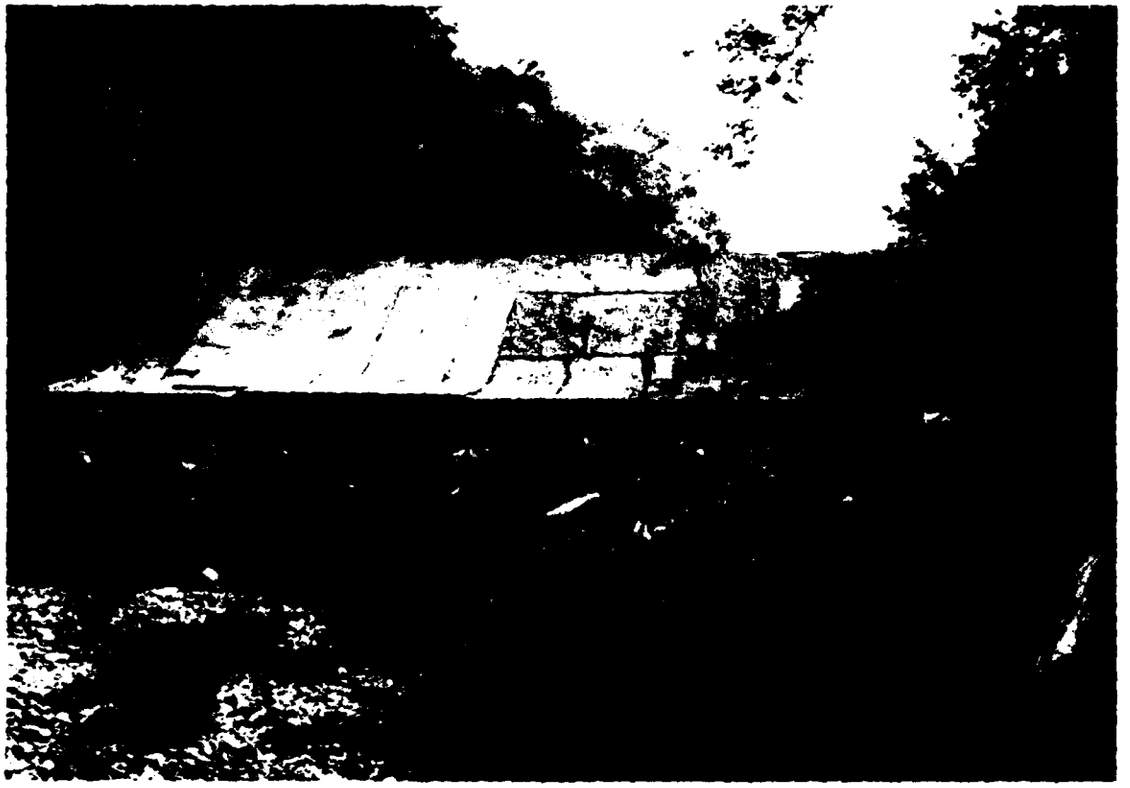
Name of Dam Warren Mill Dam NJ 00765

State Located New Jersey
County Located Warren/Hunterdon
Coordinates Lat. 4038.2 - Long. 7507.2
Stream Musconetcong River
Date of Inspection 28 August 1980

ASSESSMENT OF GENERAL CONDITIONS

Warren Mill Dam is assessed to be in poor overall condition although its spillway capacity is adequate to accommodate the 100-year design flood. Due to the very poor condition of the spillway and the lack of data from which to assess its stability, it is recommended that further engineering studies be undertaken in the near future. Collapse of the dam could cause substantial damage and possible loss of a few lives in the downstream industrial area. Accordingly, it is recommended that this dam be placed in the significant hazard category. Remedial action to be undertaken immediately includes 1) temporary patching of the spillway, 2) stabilization of the stilling basin with riprap, 3) removal of the sedimentation upstream of the spillway, and 4) refilling of eroded areas and removal of growth from the embankment. In addition, the seepage at the spillway toe should be monitored, and additional hydraulic studies should be undertaken in conjunction with the above-cited engineering investigation.

Abraham Perera P.E.
Project Manager



OVERVIEW WARREN MILL DAM

TABLE OF CONTENTS

FIGURES

APPENDIX

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines can be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of Phase I investigations is to identify expeditiously those dams that may pose hazards to human life or property. The assessment of the general condition of the dam is based on available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In the review of this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway test flood is based on the estimated "probable maximum flood" for the region (greatest reasonable possible storm runoff) or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
NAME OF DAM WARREN MILL DAM ID# NJ 00765

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with contract FPM-36 between Louis Berger & Associates, Inc. and the State of New Jersey and its Department of Environmental Protection, Division of Water Resources. The state, in turn, is under agreement with the U.S. Army Engineer District, Philadelphia, to have this inspection performed.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Warren Mill Dam and appurtenant structures and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Warren Mill Dam is a 330-foot-long earth and concrete structure with a maximum height of about 37.5 feet. The principal outlet consists of a sluice-gate-regulated diversion canal located at the left abutment. A relatively massive concrete and stone ogee-type spillway is located at the right abutment.

The embankment portion of the dam is about 150 feet long with a crest width of 20 feet and 3H:1V/1.5H:1V slopes upstream and downstream, respectively. The canal, which supplies water to the downstream mill, is parallel to, and about 20 feet higher in elevation, than the valley floor.

An adjoining road embankment separates the canal and valley. The 3 sluice gates, which regulate canal flow, are 4 feet by 7 feet each and are operated by a chain hoist. The concrete spillway at the right abutment is 125 feet long with a 3-foot-wide rounded crest whose elevation is 9 feet lower than the top of the dam. The 4.5-foot-thick concrete and masonry sidewalls flare away from the spillway as wingwalls upstream. The spillway slab overlies stone bedding and has a 1.5H:1V slope. The apron at the toe of the spillway is about 140 feet wide. The downstream pool bottom is about 10 feet below the elevation of the spillway apron.

b. Location

Warren Mill Dam is situated on the Musconetcong River approximately 0.9 miles upstream from its intersection with State Highway 519, near Warren Glen, New Jersey. From State Highway 519 the dam can be accessed via the entrance to the Riegal Products, Inc. property and following the trail along the canal. The dam lies across the Warren/Hunterdon County boundary about 2 miles southwest of Bloomsbury, New Jersey.

c. Size Classification

The maximum height of the dam is approximately 37.5 feet and the maximum storage is estimated to be 117 acre-feet. Therefore, the dam is placed in the small size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

The channel downstream of the dam consists of undeveloped woodland for a distance of 3,000 feet. Industrial buildings belonging to Riegal Products, Inc. are located approximately 3,500 feet downstream from the dam. These structures have a total area of 275,000 square feet and a working population of 200 people.

Most of the Reigal Products complex is situated 20 feet or more above the channel bottom. Since the dam has a very limited normal storage capacity due to heavy siltation, a breach situation would result in a discharge consisting primarily of surcharge storage and silt/mud flows. The silt and mud would be absorbed by the undeveloped area downstream and a portion of the flood wave's energy would be dissipated by the heavy woods, boulders, and an abandoned dam (approximately 2,000 feet downstream that are situated in the downstream valley. However, a failure could cause severe damage to the mill property, appurtenances, and bridges downstream and could possibly result in the loss of a few lives. Accordingly, it is recommended that this dam be classified as significant hazard.

e. Ownership

The dam is owned by Riegal Products, Inc., P.O. Box R, RD 1, Milford, N.J. 08848. The person to contact is: Mr. Joseph Judge, V.P. The telephone number is (201) 995-2411.

f. Purpose of Dam

This dam was originally constructed for, and continues to be used as, a source of water power for Warren Mill.

g. Design and Construction History

Little is known concerning the design or construction of the dam since the owner, who also built the dam, was unable to locate engineering data pertaining to the dam. Apparently, the dam was built around 1916 by Riegal Products, Inc. on company property, but original records relative to the construction have not been located.

h. Normal Operating Procedure

Operational procedures for the dam consist primarily of regulating flows in the canal by adjusting the height of the sluice gates at the dam.

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of the Warren Mill Dam is 148 square miles.

b. Discharge at Dam Site

Spillway capacity at maximum pool elevation is 12,150 cfs.

c. Elevations (feet above MSL)

Top of dam - 250
Principal spillway crest - 241
Streambed at centerline of dam - 212.5

d. Reservoir

Length of maximum pool (top of dam) - 2,400 feet
Length of normal pool (principal spillway crest) - 1,500 feet

e. Storage (acre-feet)

Top of dam - 117
Normal pool - 28

f. Reservoir Surface (acres)

Top of dam - 14.3
Normal pool - 5.5

g. Dam

Type - Earth with concrete and masonry spillway
Length - 330 feet
Structural height - 37.5 feet
Top width - 20 feet
Side slopes - 3H:1V/1.5H:1V - upstream/downstream
Zoning - Unknown
Impervious Core - Unknown
Grout curtain - Unknown

h. Diversion and Regulating Canal

Sluice-gate-controlled canal located at left abutment.

i. Spillway

Type - Concrete ogee weir with masonry sidewalls
Weir Length - 125 feet
Gates - None
U/S channel - Reservoir
D/S channel - Natural channel

j. Regulating Outlets

Three sluice-gates (4.0 feet by 7.0 feet) at left abutment.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Information pertaining to the design was not available for review. An extensive search failed to locate any design data, and it appears that the dam may have been constructed without a permit. However, a geotechnical review provided an overall assessment of probable foundation conditions. The dam is located in a region underlain by Pre-Cambrian gneiss. The overburden in the valley consists of recent alluvium of sand and gravel stream deposits underlain by a residual weathered gneissic soil that is sandy silt and clays with small to medium-sized rock fragments. It is not known if the dam was constructed on the existing overburden, but it grades into bedrock outcrops on the steep valley walls at both abutments.

2.2 CONSTRUCTION

No information was obtained pertaining to the construction. Field measurements provided sufficient as-built data to assess the hydraulic capacity of the spillways.

2.3 OPERATION

There is no information available pertaining to operations at the damsite other than those procedures relative to regulating the height of the sluice gates.

2.4 EVALUATION

a. Availability

There is insufficient engineering data available to fully assess the design of the dam or to determine its structural integrity. Nothing is known regarding the composition of the embankment, including zoning, cutoffs, permeability, etc., or the upstream slopes, core, or footings of the spillway structure.

b. Adequacy

The information available to assess the dam is considered inadequate. Although it is possible to perform an evaluation of the dam's external condition based on visual observations, unless additional construction or design data can be located by the owners, it is felt that further engineering studies of the dam should be performed as recommended in Section 7.

c. Validity

No design information was available for evaluation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspection of the Warren Mill Dam was conducted on 28 August 1980. Although the general condition of the embankment was considered fair, the concrete spillway is in very poor condition: extensive concrete deterioration was noted. Although the reservoir water level was 2 feet below the spillway crest at the time of the inspection, a 4-foot-deep pool of water was located at the spillway toe, apparently the result of seepage through or under the spillway section.

b. Dam

The earth embankment has a crest width of about 20 feet, which is slightly matted from vehicle use. Heavy brush was noted growing on both the upstream and downstream slopes with large-diameter trees also noted on the downstream side. The alignment of the dam is satisfactory and the upstream face has a layer of riprap placed along the level of the normal pool. No cracking, sloughing, or seepage was observed on the downstream slope of the embankment, although some erosion was noted in the vicinity of the spillway left sidewall and behind the downstream end of the right sidewall.

c. Appurtenant Structures

The sluice gates at the left abutment appear to be in good condition despite light rusting and the need of a fresh coat of paint. The wooden gates and steel slides, pulleys, gratings, and beams all appeared in good operable condition. The chain hoist appeared to be new, as did some of the cable and locks. The 125-foot-long spillway at the right abutment is in very poor condition, exhibiting severe concrete deterioration. The side and wingwalls are severely spalled and weathered in the area of the normal pool water line. The masonry mortar is cracked and missing from many areas of the left wall.

The right wall exhibits large open cold joints, surface cracking, and spalling. The right downstream footwall is undercut at its junction with the embankment. The spillway crest, slab, and apron are cracked and broken with the 3-inch-thick concrete surface slab missing from two-thirds of the spillway slope. Large open cold joints and structural cracks were observed over the entire 10-inch-thick reinforced concrete base course of the spillway. Several large holes in the concrete were noted (one as deep as 3 feet) through which the underlying stone bedding could be seen. The surface of the base concrete was extremely rough and broken, and reinforcing steel was exposed in several areas. The toe of the apron also appeared very rough with the surface courses undercut, and the aggregate is weathering out of the structure. The spillway apron was about 6 feet above the water level in the pool at the time of the inspection. The sides of the pool are littered with some debris and portions of the pool are heavily silted. It is unknown if the shape and depth of the pool were scoured out or originally designed to the present configuration as a stilling basin.

d. Reservoir

The reservoir at present is so badly silted that at the time of the inspection, with the water level only 2 feet below the spillway crest, only a narrow river of water existed in the impoundment area and along the face of the dam to the canal. Three-fourths of the upstream side of the spillway was silted to within 20 inches of the crest elevation.

e. Downstream Channel

The downstream channel is confined in a narrow (about 200 feet wide) steep-sided gorge. It is completely uninhabited as far downstream as the mill, some 3,500 feet away. The valley floor and sides are heavily wooded and the channel is very stony. The remnant of another smaller earth dam is located about 2,500 feet downstream. The downstream dam appears to be about 15 to 20 feet high with a 30-foot-wide channel near the left abutment.

SECTION 4 - OPERATION PROCEDURES

4.1 PROCEDURES

Flows in the canal, and consequently water elevations in the impoundment, are regulated by personnel employed at the mill downstream. Regulation of the sluice gates is accomplished by means of a chain hoist and is performed in response to reservoir inflow in conjunction with demands at the mill. A low-water-level warning system alerts operating personnel to drops in available water.

4.2 MAINTENANCE OF DAM

No details or records of formal maintenance procedures at the dam were available to the inspection team. Based on visual observations, it appears that no maintenance has been performed on the dam or concrete spillway for a considerable length of time.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating components at the dam are the sluice gates. Although no formal maintenance procedures are in effect, visual observations of the condition and age of the equipment indicate that this facility is well maintained and its operating components are apparently replaced frequently.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

Although there is a warning system to alert operating personnel when the water level in the canal drops too low, apparently no such system exists to notify them of excessively high reservoir water levels. However, frequent monitoring of reservoir inflow is necessary for proper regulation of flows in the canal and unusual or dangerous conditions would be reported to the mill and downstream authorities by the operators. (See also Section 7.2b.)

4.5 EVALUATION

The present operational procedures with respect to water regulation appear adequate given the regularity with which they are performed. However, the apparent lack of maintenance should be corrected immediately in view of the existing condition of the spillway section. In addition, operating personnel should be instructed in dam inspection procedures. Annual inspections should be performed and responsive reports maintained in order to provide continuity of surveillance of the dam's condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

Pursuant to the Recommended Guidelines for Safety Inspection of Dams, Warren Mill Dam is a small size and significant hazard. Accordingly, the inspecting engineers chose the 100-year frequency storm as the design flood. Inflow to the reservoir for the selected storm was computed utilizing precipitation data from Technical Publication 40 and Technical Memo NWS Hydro-35 by the HEC-1 computer program, which gave a peak inflow of 5,872 cfs, which when routed through the reservoir reduces the peak discharge slightly. As the spillway capacity is 12,150 cfs, it can accommodate the 100-year design flood.

b. Experience Data

There are no streamflow records available for this site, nor have records been kept regarding the dam's hydraulic performance since its construction.

c. Visual Observations

Although the spillway capacity of the dam is quite large, it is felt that the poor condition of the spillway could result in a failure at this structure long before the embankment overtopping would occur.

d. Overtopping Potential

Employing the discharge and spillway capacities contained herein, no overtopping would occur in the event of the 1 in 100 year frequency storm.

e. Drawdown

To dewater the lake, the sluice gates in front of the canal would have to be removed. Drawdown is possible to elevation 231 and would take approximately 1 hour to accomplish.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

As indicated in Section 3, the embankment and sluice gates are in good condition but the large overflow spillway is in very poor condition. Since the protective surface concrete slab is missing from two-thirds of the spillway, the exposed base course is extremely vulnerable and in danger of failure due to its advanced structural and surface deterioration. It is the opinion of the inspection team that severe storms would continue to cause additional deterioration and that portions of the spillway would eventually fail. The integrity of the structure is further jeopardized by the fact that the entire upstream side is silted in almost to the spillway crest elevation, which imparts a substantial additional static load on the spillway structure.

b. Design and Construction Data

As no design data were available relating to the concrete spillway, little can be deduced about the structural stability, except that portions of the crest and base slab exhibit differential movement. Since nothing is known about the internal composition and configuration of the structure, its continued integrity must be considered extremely questionable in view of its present condition. Further investigation and in-site tests of the spillway and foundation would be required to verify, with any reliability, the long-term stability. No data were located concerning the original construction.

c. Operating Records

No formal records exist. The dam appears to have performed satisfactorily under all past flooding conditions, although it is completely unknown what failures or repairs have occurred in the past.

d. Post Construction Changes

There is no record of post construction changes at the dam. Based on visual observations, there do not appear to have been any recent structural modifications. However, variations in the composition of the spillway walls suggest that the height of the dam may have been increased some time in the past.

e. Seismic Stability

Although the continuing stability of the spillway is questionable, the dam is apparently stable under the existing static conditions. Experience indicates that dams located in Seismic Zone 1 are negligibly susceptible to seismic forces if they are stable under static conditions. However, seismic loading should be included in further stability studies as a matter of record.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/ REMEDIAL ACTIONS

7.1 DAM ASSESSMENT

a. Safety

Subject to the inherent limitations of the Phase I visual inspection and the fact that little cogent design or construction information is available, Warren Mill Dam is considered to be in fair to very poor condition, and the continued stability of the spillway structure is thought to be extremely questionable. Although the spillway can accommodate the 100-year design flood, its advanced state of deterioration is such that structural failure is considered more likely to occur than dam overtopping. A breach at the spillway would send a wall of mud and silt some distance downstream, but the extensiveness of downstream damage would be more a function of the surcharge storage at the time of collapse than the normal impoundment capacity.

b. Adequacy of Information

Except for what was visually observed, little information was available, as no design data, design drawings, or studies were located. Since a cogent analysis of the spillway structure's stability is impossible without additional information, and, the condition of, and load on, the structure make its integrity questionable, the available data are deemed inadequate and further studies are recommended as indicated below.

c. Urgency

Further studies should be undertaken very soon in view of the dam's hazard assessment and overall condition. It is recommended that the remedial measures delineated below be undertaken within the time frames indicated.

d. Necessity for Further Study

Because the dam's structural stability cannot be established with reasonable reliance due to the lack of data, the obtaining of additional information and the undertaking of further studies are hereby recommended. The information obtained should include that data necessary to perform stability analysis of the spillway as well as an evaluation of repairs necessary to restore the structure to a safe and effective component of this dam.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

As stated above, additional engineering studies should be implemented in view of the deteriorated condition of the spillway and the lack of data with which to establish its stability. Although the spillway can accommodate the design flood, the hydraulic capacity is considered subordinate to structural integrity and should be addressed accordingly.

a. Recommendations

- Temporary concrete patching of the deteriorated portions of the spillway should be undertaken immediately to forestall further damage.

The below-listed actions should be undertaken in the near future:

- Engineering studies, in conjunction with the structural and foundation investigations, in order to plan and design long-term repairs for the spillway structure.

- Removal of the heavy siltation on the upstream side of the spillway to reduce the load on the structure and to increase storage capacity.

- Monitoring of the seepage at the toe of the spillway, both before and after the removal of the silt behind the spillway, and implementation of a grouting program, if warranted.

- Stabilization of the downstream stilling basin below the apron with riprap to prevent further scouring.

- Regrading of the eroded areas behind the spillway sidewalls and protection of these areas with stone riprap.

- Removal of the trees growing on the embankment portion of the dam.

b. O&M Maintenance and Procedures

The owner should institute O&M procedures in conjunction with their present operations such that regular dam inspections are conducted and routine maintenance and remedial actions are accomplished on a timely basis. Inspection and maintenance checklists should be kept in order to provide continuity in the data regarding the dam's condition in the future.

The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

The owner should also develop an emergency action plan and downstream warning system.

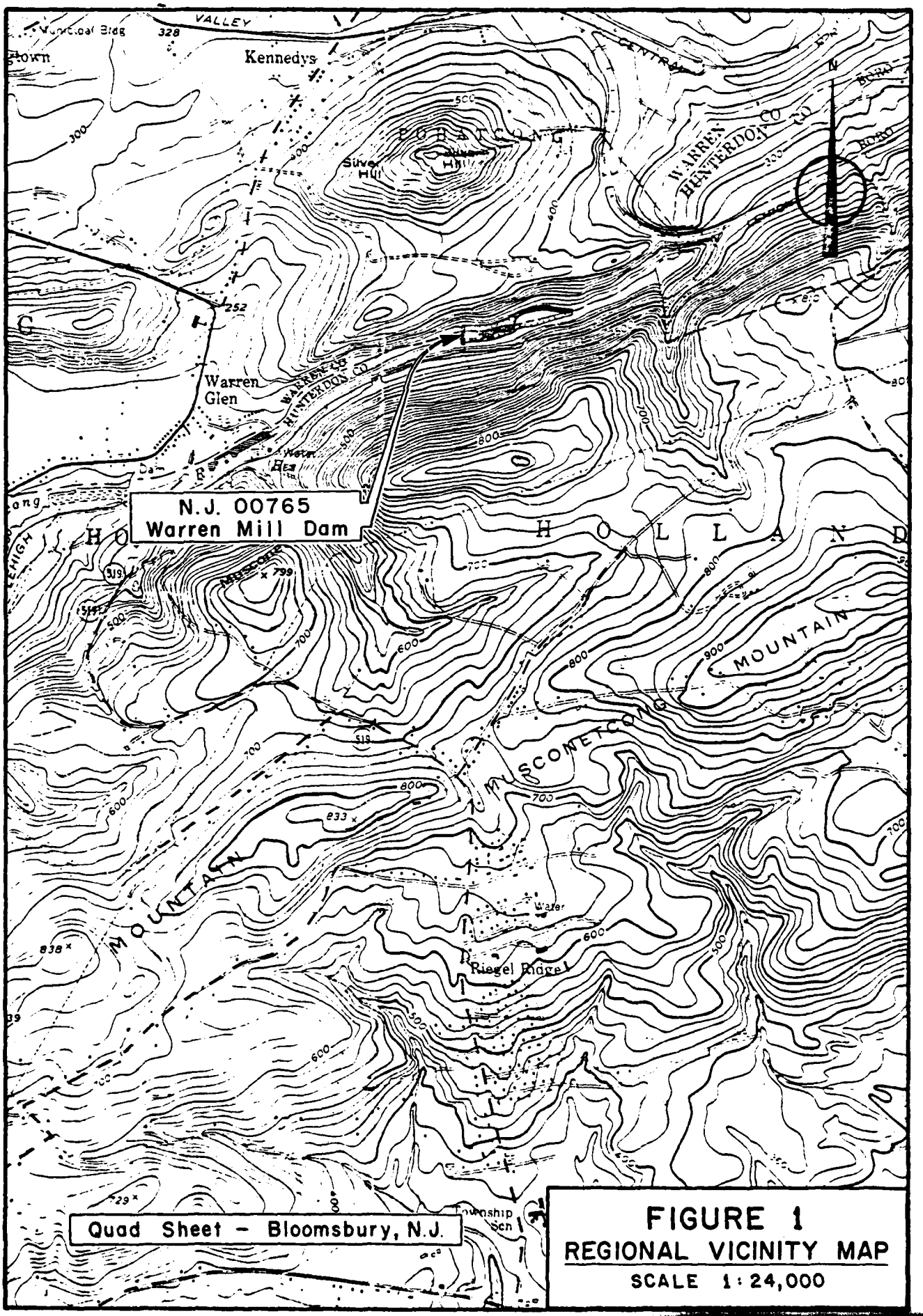
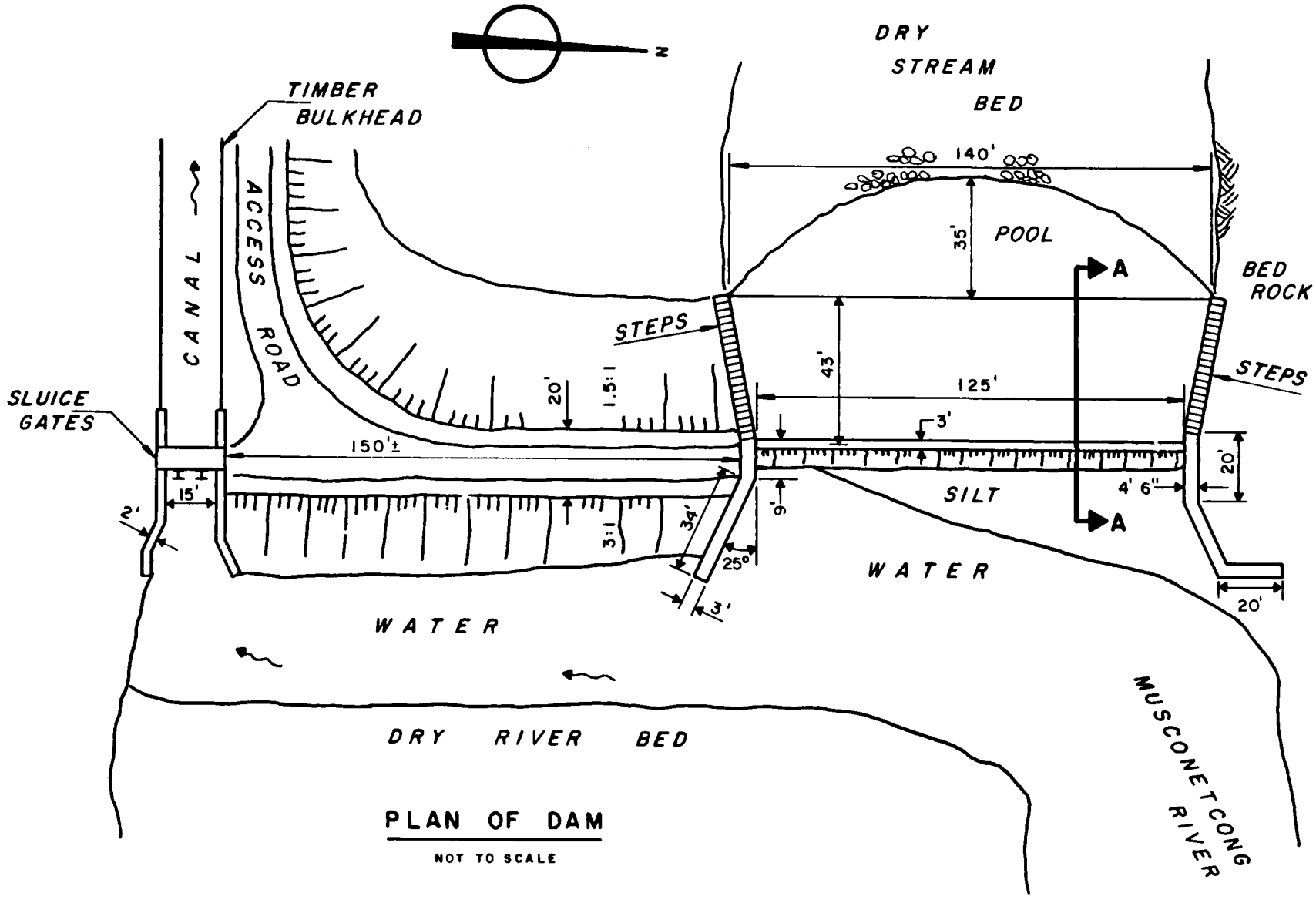


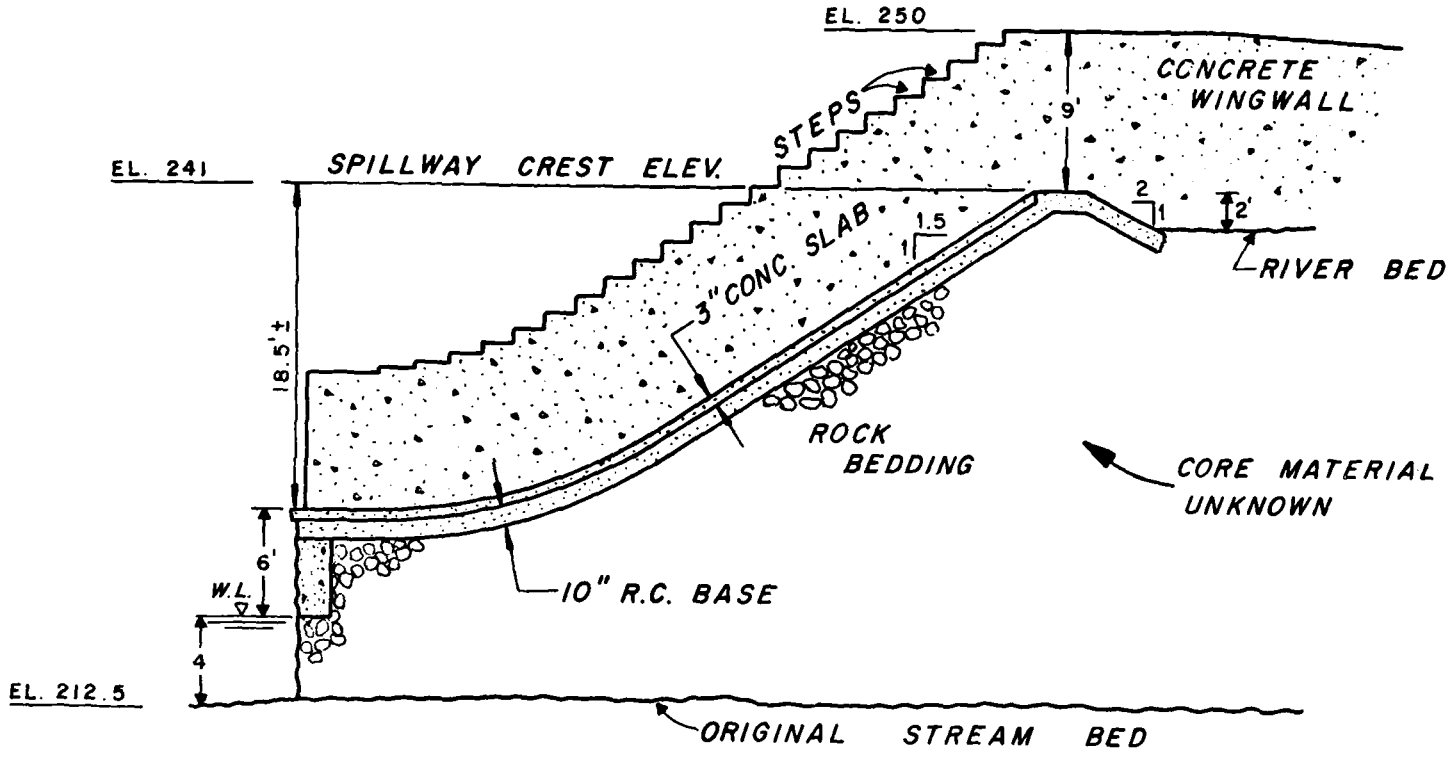
FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24,000



PLAN OF DAM

NOT TO SCALE

FIGURE 2



SECTION A-A

NOT TO SCALE

FIGURE 3

Check List
Visual Inspection
Phase I

Name Dam Warren Mill Dam County Warren/Hunterdon State New Jersey Coordinates N.J.D.E.P.

Date(s) Inspection 8/28/80 Weather Sunny Temperature 92°

Pool Elevation at Time of Inspection 239 M.S.L. Tailwater at Time of Inspection None M.S.L.

Inspection Personnel:

A. Perera J. Greenstein

T. Chapter

D. Lang

A. Perera Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Substantial leakage noted at toe. Large pool of water present.	Heavy accumulation of silt behind the upstream spillway wall. Silt up to a few feet below crest. Seepage should be monitored.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Erosion near bottom of right spillway sidewall to embankment junction.	This erosion should be backfilled and protected with stone riprap.
DRAINS	None observed	
WATER PASSAGES	Canal and lock between spillway and left abutment. Embankment on either side of lock.	
FOUNDATION	Unknown	Bedrock likely. Bedrock evident at right side downstream from spillway toe. Rock and boulders cover the downstream channel.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Spillway ogee surface badly deteriorated. Large portion of ogee surface concrete peeled off. Coarse gravel surface of mass concrete showing	Main mass of concrete spillway appears as rock/gravel fill solidified with lean concrete. This mass was then covered over with structural concrete. Re-bars can be seen at cracks, near the ogee surface. Requires immediate patching.
STRUCTURAL CRACKING	Large and deep cracks present throughout.	
VERTICAL AND HORIZONTAL ALIGNMENT	No evidence of either movement (hor.) or settlement (vert.) in concrete portion of dam.	Some displacement of base slab.
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	Open throughout in varying degrees and badly spalled.	Requires immediate patching and eventual long term repairs.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None Observed.	Embankment extends from spillway sidewall to right abutment, from left spillway sidewall to canal lock and from left side of lock to left abutment.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Erosion near right spillway sidewall.	Probably due to rain runoff. This area is to be backfilled and protected with stone riprap.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Good except behind right sidewall of spillway.	Heavily overgrown with trees between right end of spillway and right abutment and on downstream slope between left end of spillway and left abutment. These should be removed.
RIPRAP FAILURES	None Observed.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
UPSTREAM END OF EMBANKMENT	Heavily silted. Silt accumulation up to a few feet below crest.	Silt impacting heavy load on spillway and should be removed to increase storage capacity.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good on left side of spillway to canal lock and from lock to left abutment. Fair on right side of spillway to right abutment.	
ANY NOTICEABLE SEEPAGE	None observed on embankment portion.	
STAFF GAGE AND RECORDER	None Observed.	
DRAINS	None Observed.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	N/A except for canal lock.	
OUTLET STRUCTURE	N/A except for canal lock.	Sluice gate structure needs paint but in good condition.
OUTLET CHANNEL	Canal lock.	
EMERGENCY GATE(Canal Lock)	Steel-framed wood sluice gates.	Gates in good condition.

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	See observations for concrete spillway portion of dam.	
APPROACH CHANNEL	Silted at dam (spillway and embankment). Channel turns left at dam and passes through canal lock.	Heavy sedimentation must be removed.
DISCHARGE CHANNEL	Large pool at toe of concrete spillway. Rocky bottom is part. Elsewhere boulders cover the surface of discharge channel.	
BRIDGE AND PIERS	None.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	N/A	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Steep slopes on both sides. Slope flat to lever near reservoir.	The reservoir is a long gorge.
SEDIMENTATION	Very heavy, particularly near the dam. Accumulation of silt up to a few feet below crest.	Entire impoundment area reduced by siltation.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Heavily wooded and covered with boulders.	Approximately 2000 feet downstream is a dam (Approximately 20 feet V: 30 feet H opening) which forms a barrier to flood flow.
SLOPES	Steep. Channel is a gorge.	Heavily wooded and rocky.
APPROXIMATE NO. OF HOMES AND POPULATION	Village of Warren Glen located from 3500 to 4500 feet downstream of dam. Channel undeveloped and heavily wooded for the first 3000 feet. Riegal Products Inc. building (approximately 20 feet above channel bottom) located 3500 feet d/s of dam. Private and highway bridges in Warren Glen village.	
	x	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None Available
REGIONAL VICINITY MAP	Available from USGS Quad. Bloomsbury, N.J.
CONSTRUCTION HISTORY	None Available
TYPICAL SECTIONS OF DAM	None Available. Based on field measurements
HYDROLOGIC/HYDRAULIC DATA	None Available
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	None Available. Based on field measurements
RAINFALL/RESERVOIR RECORDS	None Available

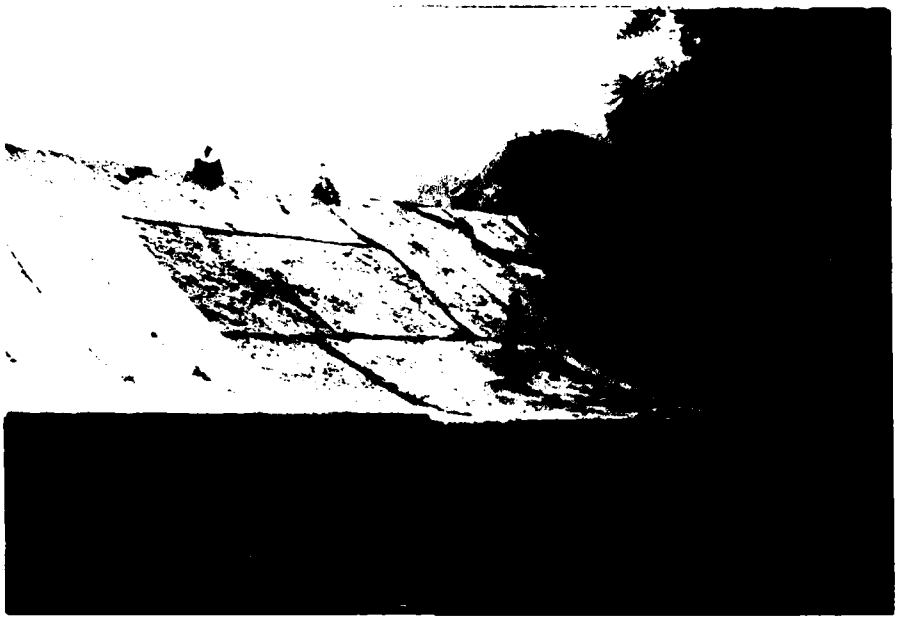
ITEM	REMARKS
SPILLWAY PLAN	None Available
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	N/A

ITEM	REMARKS
DESIGN REPORTS	None Available
GEOLOGY REPORTS	State Geologic Map & Rutgers Engineering Soil Survey
DESIGN COMPUTATIONS	None Available
HYDROLOGY & HYDRAULICS	None Available
DAM STABILITY	None Available
SEEPAGE STUDIES	None Available
MATERIALS INVESTIGATIONS	None Available
BORING RECORDS	None Available
LABORATORY	None Available
FIELD	None Available
POST-CONSTRUCTION SURVEYS OF DAM	None Available
BORROW SOURCES	None Available

ITEM	REMARKS
MONITORING SYSTEMS	Low water level warning system
MODIFICATIONS	None Available
HIGH POOL RECORDS	None Available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None Available
PRIOR ACCIDENTS OR FAILURE OF DAM	None Available
DESCRIPTION	None Available
REPORTS	None Available
MAINTENANCE	None Available
OPERATION	None Available
RECORDS	None Available

August, 1980
View of Reservoir from Spillway Crest

August, 1980
Siltation at Spillway Crest



August, 1980

View of Spillway Deterioration

August, 1980

Undercut Slab - Spillway Toe

August, 1980

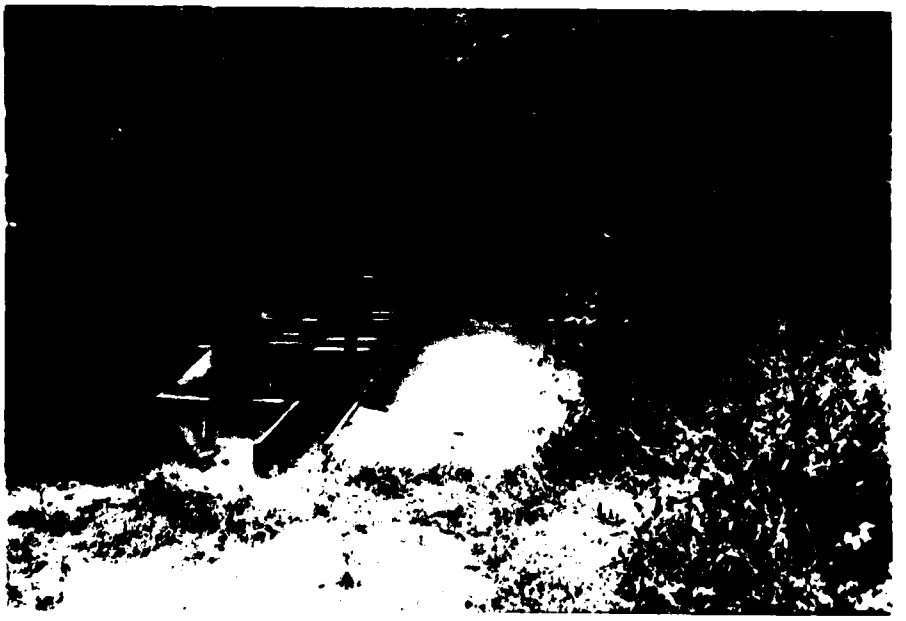
Base Slab Displacement - Spillway Crest

August, 1980

Structural Cracking Near Right Wingwall

August, 1980

Embankment Crest from Spillway Crest



August, 1980

Sluice Gates - Left Abutment

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 148 sq. mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 241 MSL (28 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 250 MSL (117 acre-feet)

CREST: Spillway

a. Elevation 241 MSL
b. Type Concrete ogee weir
c. Width 3 feet
d. Length 125 feet
e. Location Spillover Right abutment
f. Number and Type of Gates None

OUTLET WORKS: Diversion Canal

a. Type 3 4'x7' sluice gates
b. Location Left abutment
c. Entrance inverts 234
d. Exit inverts 234
e. Emergency draindown facilities Same

HYDROMETEOROLOGICAL GAGES: None

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 12,150 cfs

BY D. LONG DATE SEPT. '60 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A1 OF A14

CHKD. BY _____ DATE _____ WARREN MILL DAM PROJECT C1961

SUBJECT UNITGRAPH SUPPLIED BY CORPS OF ENGINEERS

3 Hour Unit Hydrograph
Musconetcong River
Near Bloomsbury, N.J.
Drainage Area 117.4 Sq. Mi.
From House Document 522

Hour	Discharge
0	0
3	1000
6	2500
9	2750
12	2400
15	1800
18	1600
21	1600
24	1800
27	1800
30	1600
33	1400
36	1150
39	950
42	800
45	650
48	500
51	400
54	300
57	200
60	100
63	0

BY J.C.L.L. DATE 4/...81 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A2 OF A14

CHKD. BY ..... DATE ..... WARICAI MILL DAM PROJECT C262

SUBJECT 1 HR UNIT GRAPH INTERPOLATED FROM 3 HR UNIT GRAPH

1 HOUR UNIT HYDROGRAPH INTERPOLATED FROM 3 HOUR UNIT HYDROGRAPH SUPPLIED BY CORPS OF ENGINEERS

HOUR	DISCHARGE (CFS)	HOUR	DISCHARGE (CFS)
0	0	31	1550
1	325	32	1500
2	650	33	1400
3	1000	34	1300
4	1425	35	1225
5	1950	36	1150
6	2500	37	1075
7	2700	38	1000
8	2750	39	950
9	2750	40	900
10	2675	41	850
11	2525	42	800
12	2400	43	750
13	2200	44	700
14	1975	45	650
15	1900	46	600
16	1700	47	550
17	1625	48	500
18	1600	49	450
19	1550	50	425
20	1550	51	400
21	1600	52	375
22	1650	53	325
23	1700	54	300
24	1800	55	275
25	1850	56	225
26	1850	57	200
27	1800	58	175
28	1750	59	125
29	[illegible]		
30	1600		

PRECIPITATION DATA FROM TP-40 & NOAA TECHNICAL MEMORANDUM NWS HYDRO-35

TIME	PRECIPITATION	Δ	REARRANGED Δ	
1.0	3.10	3.10	.24	
2.0	4.00	0.90	.31	4
3.0	4.4	0.40	.40	3
4.0	4.71	0.31	3.1	1
5.0	4.96	0.25	.90	2
6.0	5.20	0.24	.25	5

BY D. LANG DATE Sept. '70 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 44 OF A14

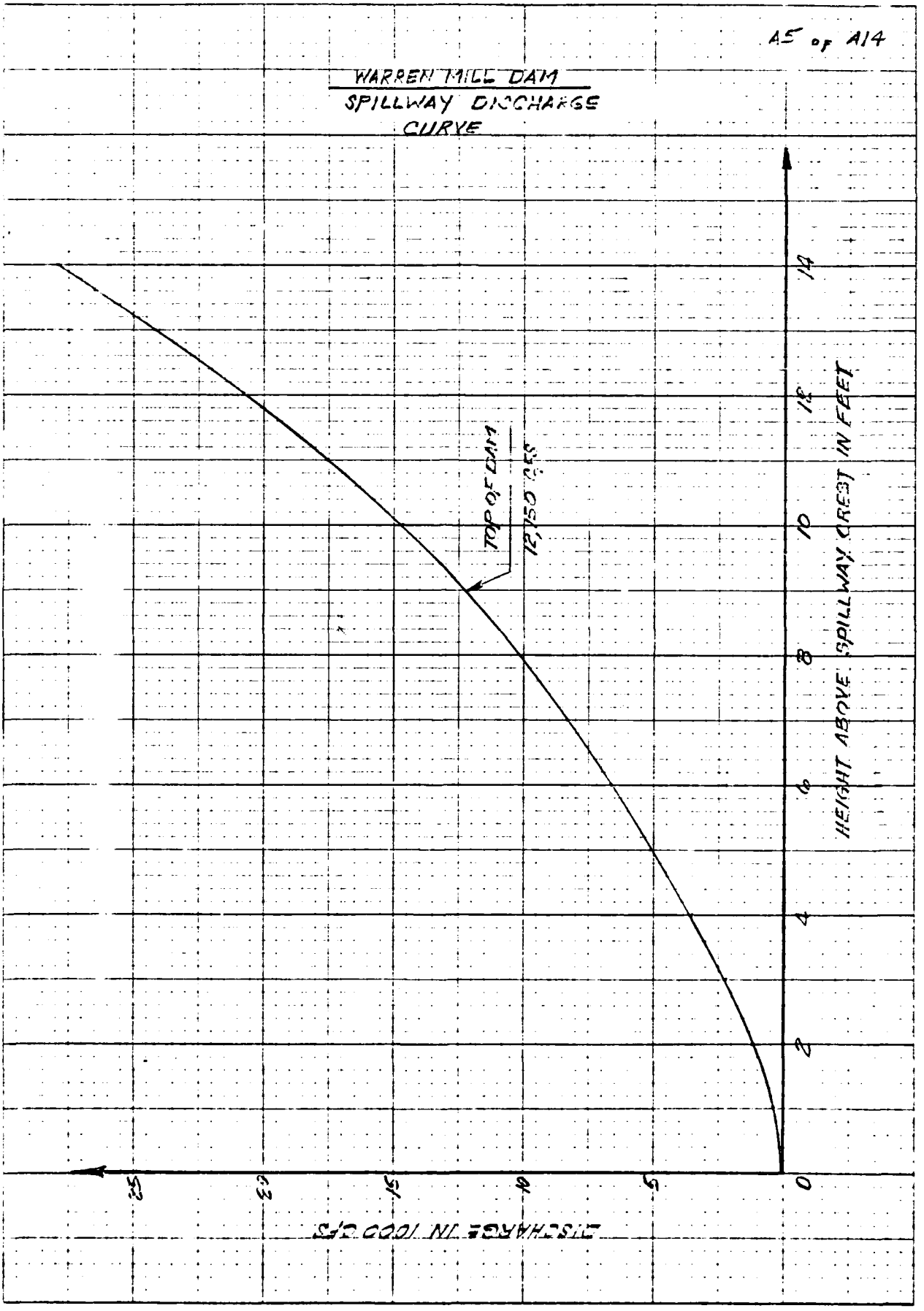
CHKD. BY _____ DATE _____ WARREN HILL DAM PROJECT C-662

SUBJECT SPILLWAY DISCHARGE

SPILLWAY CREST ELEV. = 241.0
TOP OF DAM ELEV. = 250.0
GATE INVERT ELEV. - 234.0

	SPILLWAY				OVER DAM				
ELEV.	H	C	L	Q	H	C	L	Q	ΣQ
241.0	0	3.2	125	0					0
242.0	1	3.2		400					400
243.0	2	3.3		1167					1167
244.0	3	3.4		2208					2208
245.0	4	3.5		3500					3500
246.0	5	3.6		5031					5031
247.0	6	3.6		6614					6614
248.0	7	3.6		8334					8334
249.0	8	3.6		10182					10182
250.0	9	3.6		12150					12150
251.0	10	3.6		14230	1	2.6	150	390	14620
252.0	11	3.6		16417	2			1103	17520
253.0	12	3.6		18706	3			2027	20733
255.0	14	3.6		23572	5			4360	27932

WARREN MILL DAM
SPILLWAY DISCHARGE CURVE



BY E. LANG DATE Sept. '80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A6 OF A14

CHKD. BY _____ DATE _____ WARREN MILL DAM PROJECT 0262

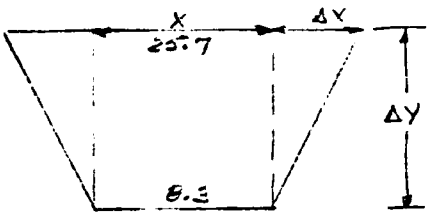
SUBJECT SURCHARGE STORAGE

AREA OF LAKE @ ELEV. 241.0 = 8.3 AC.

AREA OF CONTOUR 230.0 = 0C.

EL 260

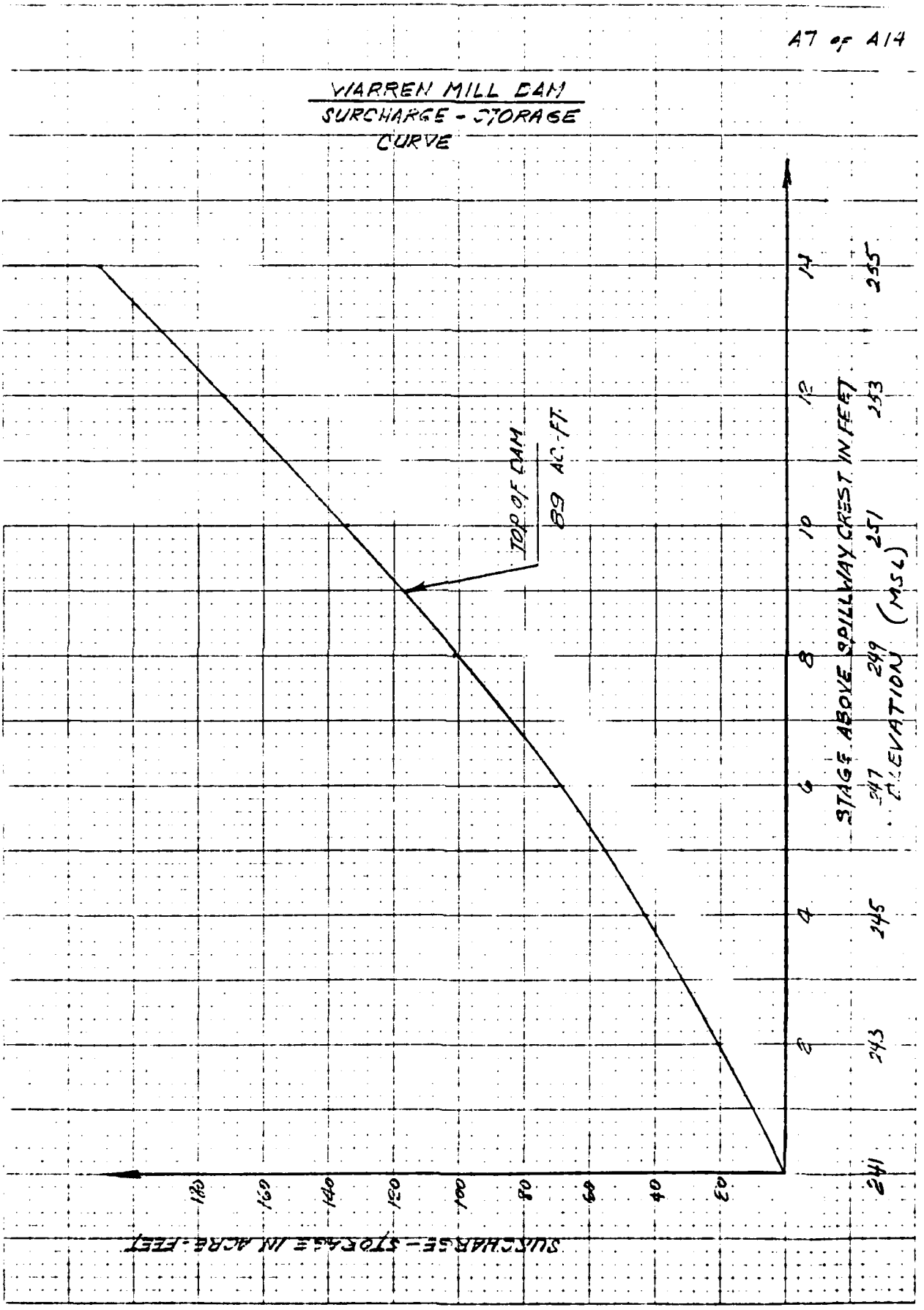
EL 240



$$\Delta V = (X + \Delta X)\Delta Y$$

ELEV.	Y	AREA (ACRES)	SURCHARGE STORAGE (AC.-FT.)	TOT. STORAGE (AC-FT
241	0	9.17	0	25
242	1	10.04	9.6	37.6
243	2	10.91	20.1	48.1
244	3	11.78	31.4	59.4
245	4	12.65	43.6	71.6
246	5	13.52	56.7	84.7
247	6	14.39	70.7	98.7
248	7	15.26	85.5	113.5
249	8	16.13	101.2	129.2
250	9	17.00	117.5	145.5
251	10	17.87	135.2	163.2
252	11	18.74	153.5	181.5
253	12	19.61	172.7	200.1
254	13	20.48	192.7	220.7
255	14	21.35	213.6	241.0

WARREN MILL DAM
SURCHARGE - STORAGE CURVE



10 Squares to the Inch

BY E. LANG DATE Sept. '80 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A5 OF A14

CHKD. BY _____ DATE _____ WARREN MILL DAM PROJECT C-162

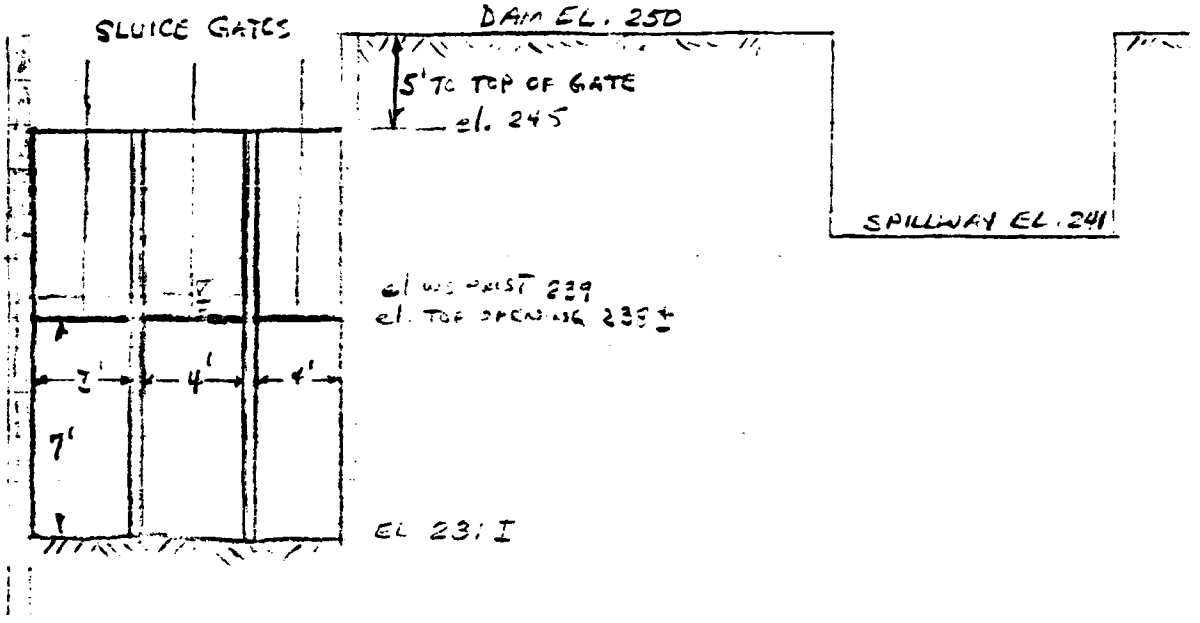
SUBJECT SUMMARY OF HEC-1 INPUT

ELEV. (MSL)	HEIGHT ABOVE SPILLWAY CREST (FT)	SURCHARGE STORAGE (AC-FT.)	DISCHARGE CFS
241	0	0	0
243	2	20	1167
245	4	44	3500
247	6	71	6614
249	8	101	10182
250	9	118	12150
251	10	135	14620
253	12	173	20733
255	14	214	27932

BY JC DATE 4/29/51 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A-7 OF A14

CHKD. BY ____ DATE ____ WARREN HILL DAM PROJECT C-664

SUBJECT DRAWDOWN



Σ STORAGE 28 AC-FT.

1. DRAWDOWN FROM EL. 241 TO EL. 238 ORIFICE FLOW

$\Delta h = 6.5$ TO 3.5

$$Q = \frac{CA\sqrt{2g}h_1}{2} + \frac{CA\sqrt{2g}h_2}{2} = \frac{.52\times(21+28+28)\left[20+15\right]}{2}$$

$Q_{AVG} = 700$ cfs

Δ STORAGE = ~ 10 AC-FT.

2. DRAWDOWN FROM EL. 238 TO 231 WEIR FLOW

$Q = CLH^{3/2}$ Assume Broad Crested Weir Condition

$H = 7$ TO 0

$Q_1 = 2.6 \times 11 \times 7^{3/2} = 530$ cfs

$Q_2 = 0$

$Q_{AVG} = 530 + 0 / 2 = 265$ cfs

Δ STORAGE = ~ 19 AC-FT

$$TIME = \frac{10\times 43{,}560}{700\times 3600} + \frac{19\times 43{,}560}{265\times 3600} = .17 + .82 = .99 \text{ Hr}$$

SAY 1 HOUR

BY ____ DATE ____ **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A10 OF A14

CHKD. BY ____ DATE ____ WARREN MILL DAM PROJECT E-162

SUBJECT HEC1 DB

```
A1  WARREN MILL DAM
A2  HEC1DB 100 YR
J.  CERAVOLO  APRIL 15 1981
B     100       1       0       0       0       0       0       0       0       0
B1      5
J       1       1       1
J1     .5
K       0       1                                       1
K1  INFLOW HYD TO RESERVOIR
M       0      -1   126.3       0
O       6
O1    .24     .31     .40     3.1     .90     .25
T                                                     .5      .1
U      60
U1      0     325     650    1000    1425    1950    2500    2700    2750    2750
U1   2675    2525    2400    2200    1975    1800    1700    1625    1600    1550
U1   1550    1600    1650    1700    1800    1850    1850    1800    1700    1650
U1   1600    1550    1500    1400    1300    1225    1150    1075    1000     950
U1    900     850     800     750     700     650     600     550     500     450
U1    425     400     375     325     300     275     225     200     175     125
X       0       0       1
K       1       2                                       1
K1  ROUTED FLOW THROUGH RESERVOIR
Y                               1       1
Y1      1                                              28      -1
Y4    241     243     245     247     249     250     251     252     253     255
Y5      0    1167    3500    6614   10182   12150   14620   17520   20733   27932
$S      0      28      48      72      99     146     163     201     241
$E    231     241     243     245     247     250     251     253     255
$$    241
$D    250
K      99
```

SUB-AREA RUNOFF COMPUTATION

PRECIP DATA

NP	STORM	DAJ	DAK
6	0.00	0.00	0.00

GIVEN UNIT GRAPH, NUHOG= 60

0.	325.	650.	1000.	1425.	1950.	2500.	2700.	2750.	2750.
2675.	2525.	2400.	2200.	1975.	1800.	1700.	1625.	1600.	1550.
1550.	1600.	1650.	1700.	1800.	1850.	1850.	1800.	1700.	1650.
1600.	1550.	1500.	1400.	1300.	1225.	1150.	1075.	1000.	950.
900.	850.	800.	750.	700.	650.	600.	550.	500.	450.
425.	400.	375.	325.	300.	275.	225.	200.	175.	125.

UNIT GRAPH TOTALS 75575. CFS OR 0.93 INCHES OVER THE AREA

RECESSION DATA

STRTQ= 0.00 GRCSN= 0.00 RTIOR= 1.00

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME				
0.	0.	6.	60.	602.	1279.	2031.	2921.	3991.	5088.
5655.	5850.	5872.	5738.	5461.	5174.	4776.	4321.	3938.	3689.
3519.	3436.	3346.	3333.	3413.	3517.	3631.	3813.	3930.	3949.
3862.	3683.	3556.	3445.	3337.	3222.	3032.	2826.	2653.	2491.
2330.	2174.	2055.	1946.	1839.	1732.	1625.	1518.	1411.	1303.
1196.	1090.	987.	921.	866.	808.	717.	653.	594.	503.
439.	378.	272.	63.	9.	0.	0.	0.	0	0.
0.	0.	0.	0.	0.	0.	0.	0	0	0
0.	0.	0.	0.	0.	0.	0.	0.	0	0
0.	0.	0.	0.	0.	0.	0.	0.	0.	0

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME

BY J.C. DATE 4/15/97

CHKD. BY _____ DATE _____

SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. 211 OF 224

PROJECT _____

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
100	1	0	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

INFLOW HYD TO RESERVOIR

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDQ	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	-1	126.30	0.00	126.30	0.00	0.000	0	0	0

PRECIP PATTERN

0.24	0.31	0.40	3.10	0.90	0.25

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	0.50	0.10	0.00	0.00

END-OF-PERIOD FLOW

O MO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	1.00	1	0.24	0.00	0.24	0.	1.03	3.00	51	0.00	0.00	0.00	2393.
1.01	2.00	2	0.31	0.03	0.28	0.	1.03	4.00	52	0.00	0.00	0.00	2179.
1.01	3.00	3	0.40	0.30	0.10	11.	1.03	5.00	53	0.00	0.00	0.00	1974.
1.01	4.00	4	3.10	3.00	0.10	120.	1.03	6.00	54	0.00	0.00	0.00	1843.
1.01	5.00	5	0.90	0.80	0.10	1204.	1.03	7.00	55	0.00	0.00	0.00	1731.
1.01	6.00	6	0.25	0.15	0.10	2558.	1.03	8.00	56	0.00	0.00	0.00	1616.
1.01	7.00	7	0.00	0.00	0.00	4062.	1.03	9.00	57	0.00	0.00	0.00	1434.
1.01	8.00	8	0.00	0.00	0.00	5842.	1.03	10.00	58	0.00	0.00	0.00	1306.
1.01	9.00	9	0.00	0.00	0.00	7981.	1.03	11.00	59	0.00	0.00	0.00	1188.
1.01	10.00	10	0.00	0.00	0.00	10177.	1.03	12.00	60	0.00	0.00	0.00	1006.
1.01	11.00	11	0.00	0.00	0.00	11311.	1.03	13.00	61	0.00	0.00	0.00	878.
1.01	12.00	12	0.00	0.00	0.00	11701.	1.03	14.00	62	0.00	0.00	0.00	756.
1.01	13.00	13	0.00	0.00	0.00	11743.	1.03	15.00	63	0.00	0.00	0.00	545.
1.01	14.00	14	0.00	0.00	0.00	11476.	1.03	16.00	64	0.00	0.00	0.00	126.
1.01	15.00	15	0.00	0.00	0.00	10922.	1.03	17.00	65	0.00	0.00	0.00	19.
1.01	16.00	16	0.00	0.00	0.00	10348.	1.03	18.00	66	0.00	0.00	0.00	0.
1.01	17.00	17	0.00	0.00	0.00	9552.	1.03	19.00	67	0.00	0.00	0.00	0.
1.01	18.00	18	0.00	0.00	0.00	8643.	1.03	20.00	68	0.00	0.00	0.00	0.
1.01	19.00	19	0.00	0.00	0.00	7875.	1.03	21.00	69	0.00	0.00	0.00	0.
1.01	20.00	20	0.00	0.00	0.00	7378.	1.03	22.00	70	0.00	0.00	0.00	0.
1.01	21.00	21	0.00	0.00	0.00	7037.	1.03	23.00	71	0.00	0.00	0.00	0.
1.01	22.00	22	0.00	0.00	0.00	6872.	1.04	0.00	72	0.00	0.00	0.00	0.
1.01	23.00	23	0.00	0.00	0.00	6693.	1.04	1.00	73	0.00	0.00	0.00	0.
1.02	0.00	24	0.00	0.00	0.00	6666.	1.04	2.00	74	0.00	0.00	0.00	0.
1.02	1.00	25	0.00	0.00	0.00	6805.	1.04	3.00	75	0.00	0.00	0.00	0.
1.02	2.00	26	0.00	0.00	0.00	7033.	1.04	4.00	76	0.00	0.00	0.00	0.
1.02	3.00	27	0.00	0.00	0.00	7263.	1.04	5.00	77	0.00	0.00	0.00	0.
1.02	4.00	28	0.00	0.00	0.00	7625.	1.04	6.00	78	0.00	0.00	0.00	0.
1.02	5.00	29	0.00	0.00	0.00	7861.	1.04	7.00	79	0.00	0.00	0.00	0.
1.02	6.00	30	0.00	0.00	0.00	7898.	1.04	8.00	80	0.00	0.00	0.00	0.
1.02	7.00	31	0.00	0.00	0.00	7723.	1.04	9.00	81	0.00	0.00	0.00	0.
1.02	8.00	32	0.00	0.00	0.00	7367.	1.04	10.00	82	0.00	0.00	0.00	0.
1.02	9.00	33	0.00	0.00	0.00	7112.	1.04	11.00	83	0.00	0.00	0.00	0.

1.02	10.00	34	0.00	0.00	0.00	6891.	1.04	12.00	84	0.00	0.00	0.00	0.
1.02	11.00	35	0.00	0.00	0.00	6675.	1.04	13.00	85	0.00	0.00	0.00	0.
1.02	12.00	36	0.00	0.00	0.00	6444.	1.04	14.00	86	0.00	0.00	0.00	0.
1.02	13.00	37	0.00	0.00	0.00	6064.	1.04	15.00	87	0.00	0.00	0.00	0.
1.02	14.00	38	0.00	0.00	0.00	5651.	1.04	16.00	88	0.00	0.00	0.00	0.
1.02	15.00	39	0.00	0.00	0.00	5306.	1.04	17.00	89	0.00	0.00	0.00	0.
1.02	16.00	40	0.00	0.00	0.00	4981.	1.04	18.00	90	0.00	0.00	0.00	0.
1.02	17.00	41	0.00	0.00	0.00	4661.	1.04	19.00	91	0.00	0.00	0.00	0.
1.02	18.00	42	0.00	0.00	0.00	4348.	1.04	20.00	92	0.00	0.00	0.00	0.
1.02	19.00	43	0.00	0.00	0.00	4110.	1.04	21.00	93	0.00	0.00	0.00	0.
1.02	20.00	44	0.00	0.00	0.00	3892.	1.04	22.00	94	0.00	0.00	0.00	0.
1.02	21.00	45	0.00	0.00	0.00	3678.	1.04	23.00	95	0.00	0.00	0.00	0.
1.02	22.00	46	0.00	0.00	0.00	3464.	1.05	0.00	96	0.00	0.00	0.00	0.
1.02	23.00	47	0.00	0.00	0.00	3250.	1.05	1.00	97	0.00	0.00	0.00	0.
1.03	0.00	48	0.00	0.00	0.00	3035.	1.05	2.00	98	0.00	0.00	0.00	0.
1.03	1.00	49	0.00	0.00	0.00	2821.	1.05	3.00	99	0.00	0.00	0.00	0.
1.03	2.00	50	0.00	0.00	0.00	2607.	1.05	4.00	100	0.00	0.00	0.00	0.
									SUM	5.20	4.28	0.92	323751.
										(132.)	(109.)	(23.)	(9167.60)

CFS	11743.	11236.	8564.	4497.	323752.
CMS	333.	318.	243.	127.	9168.
INCHES		0.83	2.52	3.97	3.97
MM		21.02	64.09	100.94	100.94
AC-FT		5571.	16986.	26756.	26756.
THOUS CU M		6872.	20952.	33003.	33003.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

CFS	5872.	5618.	4282.	2248.	161876.
CMS	166.	159.	121.	64.	4584.
INCHES		0.41	1.26	1.99	1.99
MM		10.51	32.04	50.47	50.47
AC-FT		2786.	8493.	13378.	13378.
THOUS CU M		3436.	10476.	16502.	16502.

ROUTED FLOW THROUGH RESERVOIR

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

GLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

STAGE	241.00	243.00	245.00	247.00	249.00	250.00	251.00	252.00	253.00
FLOW	0.00	1167.00	3500.00	6614.00	10182.00	12150.00	14620.00	17520.00	20733.00
CAPACITY=	0.	28.	48.	72.	99.	146.	163.	201.	241.
ELEVATION=	231.	241.	243.	245.	247.	250.	251.	253.	255.

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
241.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
250.0	0.0	0.0	0.

BY _____ DATE 4/22/91
CHKD. BY _____ DATE _____
SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. A12 OF A17
PROJECT _____

BY ____ DATE 4/17

CHKD. BY ____ DATE ____

SUBJECT ____

LOUIS BERGER & ASSOCIATES INC.

WARREN MILL DAM

HEC1 DB OUTPUT

SHEET NO. A13 OF A14

PROJECT 4262

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

MO. DA	HR. MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	1.00	1	1.00	0.	0.	28.	241.0
1.01	2.00	2	2.00	0.	0.	28.	241.0
1.01	3.00	3	3.00	6.	4.	28.	241.0
1.01	4.00	4	4.00	60.	45.	29.	241.1
1.01	5.00	5	5.00	602.	449.	36.	241.8
1.01	6.00	6	6.00	1279.	1144.	48.	243.0
1.01	7.00	7	7.00	2031.	1960.	56.	243.7
1.01	8.00	8	8.00	2921.	2787.	65.	244.4
1.01	9.00	9	9.00	3991.	3870.	75.	245.2
1.01	10.00	10	10.00	5088.	4977.	85.	245.9
1.01	11.00	11	11.00	5655.	5630.	90.	246.4
1.01	12.00	12	12.00	5850.	5833.	92.	246.5
1.01	13.00	13	13.00	5872.	5879.	93.	246.5
1.01	14.00	14	14.00	5738.	5756.	92.	246.4
1.01	15.00	15	15.00	5461.	5497.	89.	246.3
1.01	16.00	16	16.00	5174.	5200.	87.	246.1
1.01	17.00	17	17.00	4776.	4828.	84.	245.9
1.01	18.00	18	18.00	4321.	4366.	80.	245.6
1.01	19.00	19	19.00	3938.	3975.	76.	245.3
1.01	20.00	20	20.00	3689.	3708.	74.	245.1
1.01	21.00	21	21.00	3519.	3536.	72.	245.0
1.01	22.00	22	22.00	3436.	3441.	71.	244.9
1.01	23.00	23	23.00	3346.	3361.	71.	244.9
1.02	0.00	24	24.00	3333.	3328.	70.	244.9
1.02	1.00	25	25.00	3413.	3400.	71.	244.9
1.02	2.00	26	26.00	3517.	3505.	72.	245.0
1.02	3.00	27	27.00	3631.	3619.	73.	245.1
1.02	4.00	28	28.00	3813.	3789.	75.	245.2
1.02	5.00	29	29.00	3930.	3925.	76.	245.3
1.02	6.00	30	30.00	3949.	3949.	76.	245.3
1.02	7.00	31	31.00	3862.	3877.	75.	245.2
1.02	8.00	32	32.00	3683.	3704.	74.	245.1
1.02	9.00	33	33.00	3556.	3564.	73.	245.0
1.02	10.00	34	34.00	3445.	3461.	72.	245.0
1.02	11.00	35	35.00	3337.	3350.	70.	244.9
1.02	12.00	36	36.00	3222.	3238.	69.	244.8
1.02	13.00	37	37.00	3032.	3061.	67.	244.6
1.02	14.00	38	38.00	2826.	2850.	65.	244.4
1.02	15.00	39	39.00	2653.	2673.	63.	244.3
1.02	16.00	40	40.00	2491.	2511.	62.	244.2
1.02	17.00	41	41.00	2330.	2350.	60.	244.0
1.02	18.00	42	42.00	2174.	2193.	59.	243.9
1.02	19.00	43	43.00	2055.	2067.	57.	243.8
1.02	20.00	44	44.00	1946.	1960.	56.	243.7
1.02	21.00	45	45.00	1839.	1852.	55.	243.6
1.02	22.00	46	46.00	1732.	1746.	54.	243.5
1.02	23.00	47	47.00	1625.	1638.	53.	243.4
1.03	0.00	48	48.00	1518.	1531.	52.	243.3
1.03	1.00	49	49.00	1411.	1424.	51.	243.2
1.03	2.00	50	50.00	1303.	1317.	50.	243.1
1.03	3.00	51	51.00	1196.	1210.	48.	243.0
1.03	4.00	52	52.00	1090.	1110.	47.	242.9
1.03	5.00	53	53.00	987.	1008.	45	242.7
1.03	6.00	54	54.00	921.	932.	44.	242.6
1.03	7.00	55	55.00	866.	878.	43.	242.5
1.03	8.00	56	56.00	808.	820.	42.	242.4
1.03	9.00	57	57.00	717.	739.	41.	242.3
1.03	10.00	58	58.00	653.	663.	39	242.1
1.03	11.00	59	59.00	594.	607.	38.	242.0
1.03	12.00	60	60.00	503.	524.	37	241.9
1.03	13.00	61	61.00	439.	449	36	241.8

1.03	14.00	62	62.00	378.	392.	35	241.7
1.03	15.00	63	63.00	272.	298.	33	241.5
1.03	16.00	64	64.00	63.	114.	30	241.2
1.03	17.00	65	65.00	9.	4.	28	241.0
1.03	18.00	66	66.00	0.	5.	28.	241.0
1.03	19.00	67	67.00	0.	0.	28	241.0
1.03	20.00	68	68.00	0.	0.	28.	241.0
1.03	21.00	69	69.00	0.	0.	28.	241.0
1.03	22.00	70	70.00	0.	0.	28.	241.0
1.03	23.00	71	71.00	0.	0.	28.	241.0
1.04	0.00	72	72.00	0.	0.	28.	241.0
1.04	1.00	73	73.00	0.	0.	28.	241.0
1.04	2.00	74	74.00	0.	0.	28.	241.0
1.04	3.00	75	75.00	0.	0.	28.	241.0
1.04	4.00	76	76.00	0.	0.	28.	241.0
1.04	5.00	77	77.00	0.	0.	28.	241.0
1.04	6.00	78	78.00	0.	0.	28.	241.0
1.04	7.00	79	79.00	0.	0.	28.	241.0
1.04	8.00	80	80.00	0.	0.	28.	241.0
1.04	9.00	81	81.00	0.	0.	28.	241.0
1.04	10.00	82	82.00	0.	0.	28.	241.0
1.04	11.00	83	83.00	0.	0.	28.	241.0
1.04	12.00	84	84.00	0.	0.	28.	241.0
1.04	13.00	85	85.00	0.	0.	28.	241.0
1.04	14.00	86	86.00	0.	0.	28.	241.0
1.04	15.00	87	87.00	0.	0.	28.	241.0
1.04	16.00	88	88.00	0.	0.	28.	241.0
1.04	17.00	89	89.00	0.	0.	28.	241.0
1.04	18.00	90	90.00	0.	0.	28.	241.0
1.04	19.00	91	91.00	0.	0.	28.	241.0
1.04	20.00	92	92.00	0.	0.	28.	241.0
1.04	21.00	93	93.00	0.	0.	28.	241.0
1.04	22.00	94	94.00	0.	0.	28.	241.0
1.04	23.00	95	95.00	0.	0.	28.	241.0
1.05	0.00	96	96.00	0.	0.	28.	241.0
1.05	1.00	97	97.00	0.	0.	28.	241.0
1.05	2.00	98	98.00	0.	0.	28.	241.0
1.05	3.00	99	99.00	0.	0.	28.	241.0
1.05	4.00	100	100.00	0.	0.	28.	241.0

PEAK OUTFLOW IS 5879. AT TIME 13.00 HOURS

CFS	5879.	5614.	4283.	2248.	161878.
CMS	166.	159.	121.	64.	4584.
INCHES		0.41	1.26	1.99	1.99
MM		10.50	32.05	50.47	50.47
AC-FT		2784.	8496.	13378.	13378
THOUS CU M		3434.	10480.	16502.	16502.

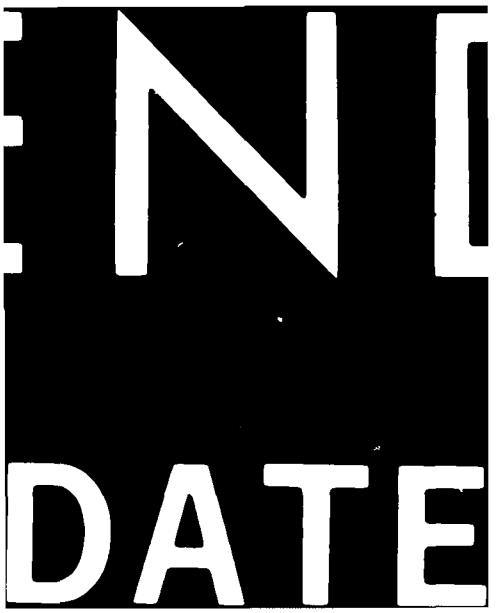
PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1
				0.50
HYDROGRAPH AT	1	126.30	1	5872.
		(327.11)		(166.26)(
ROUTED TO	2	126.30	1	5879.
		(327.11)		(166.47)(

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	241.00	241.00	250.00
STORAGE	28	28.	146
OUTFLOW	0.	0.	12150.

RATIO OF PMF	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	246.53	0.00	93.	5879.	0.00	13.00	0.00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